METHOD AND APPARATUS FOR FAST PILOT CHANNEL ACQUISITION USING A MATCHED FILTER IN A CDMA RADIOTELEPHONE

FIELD OF THE INVENTION

The present invention relates generally to digital communication. More particularly, the present invention relates to a method and apparatus for pilot channel acquisition in a spread spectrum communication system such as a code division multiple access (CDMA) cellular telephone system.

BACKGROUND OF THE INVENTION

Direct sequence code division multiple access (DS-CDMA) communication systems have been proposed for use in cellular telephone systems operating at 800 MHz and in the personal communication system (PCS) frequency band at 1800 MHz. In a DS-CDMA system, all base stations in all cells may use the same radio frequency for communication. Base stations are uniquely identified in the system by uniquely-assigned spreading codes. Two specified pseudorandom noise (PN) sequences of 2^{15} bits length are used by all the base stations. In a quadrature modulated system, one sequence is used for the in-phase (I) channel spreading of the I channel symbols and the other is used for the quadrature (Q) channel spreading of the Q channel symbols. Mobile stations in the system possess the same two 2^{15} bits length spreading codes and use them for the initial de-spread of the I and Q channels.

Before the spreading on the I and Q channels, the symbols for transmission are spread using one row of a dimension-64 Hadamard matrix, a process known as Walsh covering. When in a call, each mobile station is assigned a unique Walsh code by the base site to ensure that transmission to each mobile station within a given cell is orthogonal to transmission to every other mobile station, assuming that a different row of the Hadamard matrix is used for each mobile station. In this manner, traffic channels are established for two-way communication between a base station and a mobile station.

In addition to traffic channels, each base station broadcasts a pilot channel, a synchronization channel, and a paging channel. The pilot channel is formed by a constant level signal that is covered by Walsh code 0, which consists of all zeros. The pilot channel is commonly received by all mobile stations within range and is used by the mobile station for identifying the presence of a CDMA system, initial system acquisition, idle mode hand-off, identification of initial and delayed rays of communicating and interfering base stations, and for coherent demodulation of the synchronization, paging, and traffic channels.

Since all base stations use the same PN sequences to spread the I and Q channels, the base stations are uniquely identified by using a unique starting phase, also referred to as a starting time or phase shift, for the PN sequences. The sequences are produced at a chip rate of 1.2288 Mega-chips per second and thus repeat every 26⅔ milliseconds. The minimum time separations are 64 chips in length allowing a total of 512 different PN code phase assignments for the base stations. Other allowed time separations are 64 chips times multiples of two.

At the mobile station, the received RF signals include pilot, synchronization, paging, and traffic channels from all nearby base stations. The mobile station must identify all the pilot signals that are receivable including the pilot signal from the base station with the strongest pilot channel. In

prior art mobile stations, a correlator has been used as a receiver pilot searching element to serially search for the PN phases of the receivable pilots. Knowledge of the correct I and Q channel spreading PN phases of the base site(s) with which the mobile station communicates allows the coherent detection of all the other code channels transmitted by the base station. Incorrect I and Q channel spreading PN phases will produce no output from the correlator when used to demodulate the remaining code channels.

Because the I and Q channel spreading PN sequence phase space is large, the prior art serial correlation technique has taken a prohibitively long time to correctly locate pilot signal energy. At a minimum, with strong signals, system acquisition upon powering up the mobile station takes 2.5 seconds. With no receivable pilots present, the mobile station will continue to search the entire phase space of the I and Q channel PN sequences until a system time out occurs which may be 15 seconds. Then the mobile station may move to another RF frequency and again attempt to acquire the CDMA system. This makes it important to quickly identify whether CDMA pilots are receivable on any possible RF channel assignment.

The long time delay in system acquisition is inconvenient and undesirable for most users. A user turning on a radiotelephone expects to be able to use the radiotelephone immediately, with minimal delay. A delay of even 2.5 seconds is too long for many users and longer delays could have serious consequences, for example, for emergency "911" calls. Because of the prior art method of correlating all the spreading PN sequence phases, the long delay is inherent in prior art DS-CDMA mobile stations.

The prior art pilot channel searching method creates further limitations for all of the other uses of the pilot channel after initial system acquisition. Typical DS-CDMA mobile station receivers utilize a rake receiver having three or more independently controlled fingers which are time aligned to the correct PN sequence phases using knowledge of the pilot channel phases determined by the receiver pilot phase searching element. The rake fingers are normally assigned to the strongest rays received from all communicating base stations as determined by the receiver pilot phase searching element. Ray assignments are updated in a maintenance process using the pilot phase searching element information. If the pilot phase searching element is slow, resulting in slow maintenance of the assignment of the strongest rays to the rake fingers, the receiving performance of the mobile station is degraded under fading conditions.

Idle hand-off is the process of attaching to and listening to the paging channel of the base station with the strongest pilot as identified by the pilot searching element When the mobile station receives a page or accesses the system to place a call, it is important that the mobile station is listening to the page from or tries to access the base station associated with the strongest received pilot. This requires a fast pilot phase searching element, particularly when the mobile station is in motion.

For battery powered portable mobile stations it is also very important to conserve battery charge when waiting for pages. DS-CDMA provides a slotted mode that allows portable stations to power down except for the periods when their assigned paging slot information is transmitted by the base stations The paging slot interval can be as short as 1.28 seconds and periods of 1.28 seconds multiplied by powers of two for more battery savings. During these intervals, the mobile station "sleeps" in a low power mode.

A portable station may have to search the possible phase space of as many as twenty base stations every time it wakes